Edition 1

DRILLING WASTE in the

Mackenzie Delta (Inuvialuit Settlement Region) Region

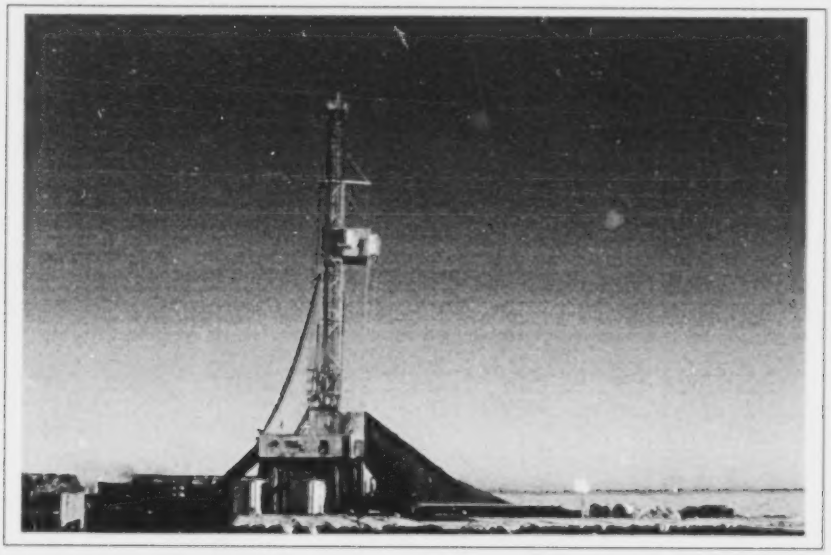
Sponsored by:
Environmental Studies Research Funds (ESRF)

DRILLING WASTE MANAGEMENT RECOMMENDED BEST PRACTICES

March 2004

105-06415/

DRILLING WASTE MANAGEMENT BEST RECOMMENDED PRACTICES



IMPORTANT: Please read, accept and comply with the following.

Disclaimer: The Drilling Waste Management Best Practices Guide is provided for informational purposes only. The information and practices in this manual, even if implemented correctly and competently, may not necessarily produce the desired results. Neither, **Environmental Studies Research Funds (ESRF)** nor any of the creators of this resource shall bear any liability whatsoever in relation to the use of, or reliance upon, this manual by others. Users of these recommended best practices shall not hold **Environmental Studies Research Funds (ESRF)** or any of the creators liable for any loss or injury incurred as a result of use of, or reliance upon, this material.

Implementation of the recommendations and procedures contained in this manual is at the sole risk of the user. While every effort has been made to ensure the accuracy of the information provided, it remains the responsibility of each individual to know and comply with all regulations. This manual reflects practices from expert sources. When there is any difference between this material and related regulations, use the regulations.

This material does not replace hands-on training, qualified technical advice or common sense. The many complex and unique situations you are involved in may require the specialized knowledge of experts. Because this material is not intended to provide detailed knowledge, or to address all possible situations, experts should be consulted as required.

Copyright © 2004 **Environmental Studies Research Funds (ESRF)**
All rights reserved. Created in Canada

This information is provided as a service to the Contractors and Consultants in the Mackenzie Delta Region and is not to be used for commercial gain.
No part of this material may be reproduced for resale.

The CD's are available through the **Environmental Studies Research Funds (ESRF)**
Website: http://www.esrfunds.org/

Prepared by Ellis & Associates Inc. (403) 816-6049 in collaboration with MegaPhone Communications

Background

Representatives from the Inuvialuit Joint Secretariat, Inuvialuit Game Council, Inuvialuit Lands Administration, Department of Indian Affairs and Northern Development, Environment Canada, and the energy industry joined forces to develop and make available a set of 'best recommended practices' for the management and disposal of drilling waste.

'Best Practices' has many meanings. In this guide, a 'best practice' is an approach to environmental risk management that:

- Undergoes continual renewal and makes maximum use of new technologies as they are developed; and,
- Uses all the knowledge and technology at one's disposal to ensure success.

The key attributes of environmental management best practices[1] when applied to drilling waste management are listed below.

Drilling waste 'Best Practices:

- Focuses on the principles of minimizing environmental impact.
- Enhances environmental performance and maintains market competitiveness.
- Enables proponents to plan and implements practical mitigation approaches that may reduce full cycle costs of drilling waste management.
- Combines the use of industrial techniques and good housekeeping principles determined to be the most effective and practical known means of reducing impacts on the environment.
- Reflects community values and traditional knowledge.
- Indicates a desired goal of performance and realistic ways to approach that goal.
- Evolves with new knowledge and the best available technology, in this ways serving as a living guide.

A **'Recommended Practice'**, when used in this guide, means:

A sub-process, practice or set of actions that will aid in fulfilling the attributes of the best practices.

The best practices of any option, includes numerous recommended practices.

[1] Modified from the *Best Environmental Management Practices for Mining in NWT*; Gartner Lee Limited, 2004, Northern Water Resources Studies Series, Water Resources Division, DIAND, Yellowknife.

Background Continued ...

A Drilling Waste Disposal Best Practices Guidelines Workshop was held in Inuvik, NWT September 2003. This guide was developed based on the input and results from the fifty participants from the Inuvaluit community, the government and the energy industry. The following chart describes the expectations raised during the workshop.

Desired Results of Using Best Practices

(N=total number of participants who responded)

Expectations	% Rating item "Important" or "Critical"	N
Must clearly ensure that human health is protected. (Local people depend on environment and wildlife).	100	37
Must be assurances that pollutants are not entering the soil or wildlife food chain.	97	39
Establish a definition of "failure" that all parties agree to.	95	38
Waste management practices must be equivalent to best practices in the country.	95	38
Acknowledge poor practices of the past and indicate how they will be avoided in the future.	93	41
Must consider long-term changes in the Mackenzie Delta Region when locating any waste disposal site.	92	38
Account for long-term changes in the Mackenzie Delta Region when locating any waste disposal site.	92	38
Design sump caps to prevent slumping, pooling and alterations to wind flow patterns.	92	38
Monitoring must be defined and consistently implemented, taking into account comparisons with surrounding conditions.	90	39
Site selection is critical: ISR approval of site locations must consider present and future concerns	89	37
Must ensure that toxics are monitored and that statistics are available	89	37
A suite of drilling waste options – a match between appropriate optio0n and specific situations.	89	37
Make sumps smaller than they were 20 years ago (smaller footprint, less waste)	87	39
Restoration of failed sumps	86	37
The eventual elimination of sump use	86	37
Choice of fluids is important: preference to fluids with low toxicity	84	36
Must consider effects of climatic change: will soil temperatures be affected?	75	37

Table of Contents

INTRODUCTION

Background iii
Guide Introduction vi
Sponsors & Recognitions viii

OPTIONS

(Presented in alphabetical order)

DOWNHOLE INJECTIONS

Description 1
Current Status 2
Pro's 3
Con's 3
Recommended Practices 4

IN-GROUND SUMPS

Single Well Sumps 5
Central & Regional Sumps 11
Sump Siting 13
Sump Design 16
Sump Construction 19
Sump Operations 20
Sump Abandonment & Restoration 22
Sump Monitoring 23
Additional Recommended Practices 24

REGIONAL TREATMENT & SITE DISPOSAL

Description 27
Current Status 27
Pro's 27
Con's 28
Recommended Practices 29

THERMAL DESORPTION / OXIDATION & INCINERATION

Description 31
Current Status 31
Pro's 32
Con's 32
Recommended Practices 33

TRUCKING OUT OF NWT

Description 35
Current Status 35
Pro 35
Con's 36
Recommended Practices 37

APPENDICIES

Glossary 39
References 42

Guide Introduction

Environmental protection

Source: Inuvialuit Harvest Study calendars by Linda Graf

Guide Purpose:

- To provide a valuable Drilling Sump Options reference tool suitable for the Mackenzie Delta (Inuvialuit Settlement Region) Region; and,
- To promote the proper management of drilling wastes.

Intended Users: The target audiences for this resource are all those with an interest or responsibility in drilling waste management.

Principles: Ideally, readers will be encouraged to use, **yet not be limited by**, the information and options presented in this guide.

Environmental Protection: No matter what their decisions and actions are, everyone is strongly encouraged to protect the environment by ensuring that all actions adhere to the following fundamental principles of proper drilling waste management:

- Minimization of surface disturbance;
- Responsible and cost effective waste disposal;
- Waste volume minimization; and,
- Re-use waste when possible.

Guide Introduction Continued ...

This guide is a reference tool that describes five options for dealing with drilling waste that may possibly be used in the Mackenzie Delta (Inuvialuit Settlement Region) Region. Presented in alphabetical order, these options include:

- Downhole Injection;
- In-Ground Sumps;
- Regional Treatment & Disposal Site – Third Party Operator;
- Thermal Desorption / Oxidation & Incineration; and,
- Trucking Out of NWT.

With each option presented, is the following information:

- A description and current status;
- Past practices;
- Related considerations;
- Pro's and con's of each option; and,
- Recommended practices to reduce impacts.

The currently available information and experience has been compiled in this guide to:

- Minimize environmental impacts;
- Assist people by sharing current available information, to make the best drilling waste choices by sharing what is now known.

Note: There is no intention to recommend any one particular option

This guide is intended to be a 'living guide'. As technology, knowledge and experience evolves, leading to new information, options and recommended practices, this guide is updated and made available.

Sponsor & Recognitions

This guide is sponsored by:

Environmental Studies Research Funds (ESRF)
Website: http://www.esrfunds.org/

Thanks to each member of the Technical Advisory Group (TAG):
(Listed in alphabetical order)

- **Jerry Bulman** – ChevronTexaco
- **Brian Heppelle** – Environment Canada, Environmental Protection Branch
- **Randy Hetman** – Shell Canada Limited
- **Robert Jenkins** – Department of Indian Affairs and Northern Development, Water Resources Division
- **Johnny Lennie** – Inuvialuit Game Council
- **Ron Lincz** – Newpark Environmental Services
- **David Milburn** – Department of Indian Affairs and Northern Development, Water Resources Division
- **Nelson Perry** – Joint Secretariat, Inuvialuit Game Council
- **Ian Scott** – Environmental Studies Research Funds, and Canadian Association of Petroleum Producers
- **Mardy Semmler** – Inuvialuit Lands Administration
- **Duane Smith** – Inuvialuit Game Council
- **Norman Snow** – Joint Secretariat, Inuvialuit Renewable Resources Committees
- **Don Thompson** – Technical Advisory Group Chair, and PetroCanada Oil & Gas
- **Aaron Trites** – Newpark Environmental Services

Special thanks to:

- **Bill McMillan** – EQUUS Group
- **Workshop Participants** – All the people who participated in the Best Management Practices Workshop

Thanks to all those people, too numerous to list, who have made this Guide possible by giving presentations, and by providing information/reference material to TAG.

This material was designed and finished by:

- **Ellis & Associates Inc. in partnership with Megaphone Communications**
  Email: ellisinc@telus.net Telephone: (403) 816 – 6049

DOWNHOLE INJECTIONS

Source: Petro-Canada

Description

Downhole Injection: The pumping of waste solids or liquids down a well and into the rock formation.

The formation being injected into must be porous, permeable and have a dense impermeable rock seal above and below it. This seal is important to ensure wastes do not migrate upward into other zones (e.g. potable water zone) or to the surface.

Most injection wells operating below fracture pressure, can only accept wastes in the form of clear fluids.

Slurry Injection Wells

Slurry injection wells that operate under fracture pressure, are not very common as the required formation characteristics are very rare. When there is enough porosity and permeability in the rock formation, and/or when there are large extensive fractures, waste slurries can be injected.

In certain formations, the waste slurry can be injected into the formation at high pressure to fracture the rock, allowing the waste slurry to be pumped into it.

Caution: This type of slurry injection must be performed under very controlled conditions to avoid any vertical fractures to the other zones.

Because of the inherent geological sensitivities, which make the life span of the facility unpredictable, fracture injection is not always a dependable long-term disposal option.

DOWNHOLE INJECTIONS Continued ...

Current Status

Currently, there are no disposal wells in the Mackenzie Delta Region. There is potential for slurry injection wells in some of the development fields during production drilling.

Slurry injection wells are currently being used in some areas of Alaska. The extensive number of wells drilled in this area has provided the geological information necessary to select suitable injection zones. Also, historically high levels of drilling activity in this region have provided economies of scale to support the cost of central injection facilities.

Pros

The primary pros of using downhole injections as a viable option for the management of drilling wastes are listed.

- **Preference** – Environmentally preferred when rock formations allow.
- **Less impact** – Reduces surface impacts.

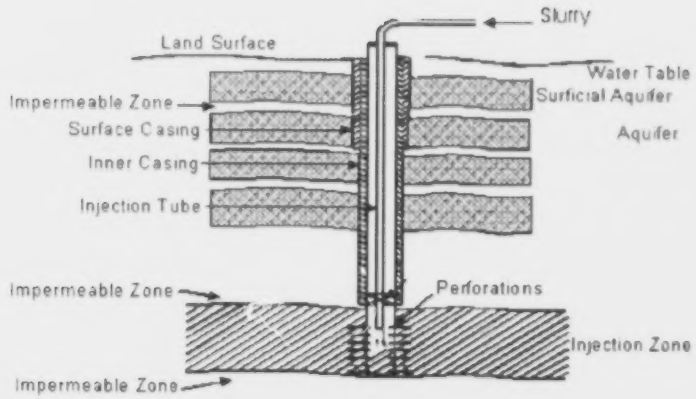
Cons

The cons of using downhole injections as a viable option for the management of drilling wastes are listed.

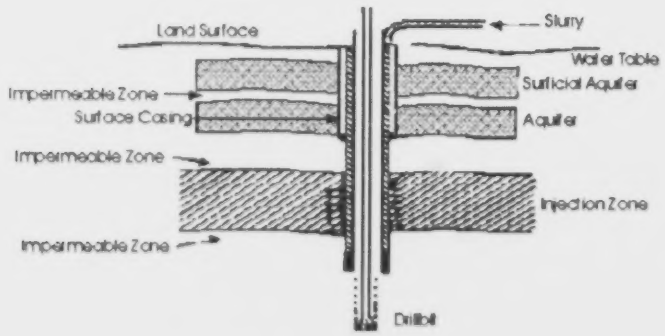
- **Specific Selection Requirements for Injection Zone** - The injection zone must be able to accept the waste.
- **Continuous Operations Requirement** – Continual operations may be required due to zone and rock seal characteristics.
- **Economics** – Large volumes of drilling waste may be required to make the cost economical due to capital and on-going infrastructure costs.
- **Risk of Injecting Out of Zone** – There is the risk that other zones get contaminated.
- **Access limitations** – Wastes generated in the summer may need to be stored and transported to a central facility when weather and conditions permit (usually the following winter).
- **Procedure limitation** – Slurry **cannot** be injected into an exploration well, while it is being drilled due to a lack of information about prospective injection zones.
- **Blockages** – Waste fluids containing solids (slurry), may plug the interconnected pores of the rock formation.

DOWNHOLE INJECTIONS Continued ...

Downhole Injection



Downhole Injection While Drilling



DOWNHOLE INJECTIONS Continued ...

Recommended Practices

Minimize the possible impacts of downhole injection by practicing the following recommendations.

- Find a zone that is geologically feasible and acceptable to regulators.
- Ensure there is a contingency back-up plan in place for the storage / disposal of the drilling waste, in case there are injection problems.
- Ensure the zone has appropriate characteristics including:
  - Is not hydrocarbon bearing (free of hydrocarbons); and,
  - Has a rock seal above and below.
- Know the pressure limitations to avoid fracturing the seals.
- Implement operational procedures to monitor performance. Indicators would include:
  - Injection volumes;
  - Pressure;
  - Fluid sampling and control;
  - Reporting; and,
  - Well-bore integrity assurance.

References & / or Related Information

Argonne National Laboratory; Environmental Assessment Division publications:

1. Brochure: *An Introduction to Slurry Injection Technology for Disposal of Drilling Wastes.* http://www.ead.anl.gov/pub/dsp_detail.cfm?PubID=1628
2. Report: *Evaluation of Slurry Injection Technology for Management of Drilling Wastes*, May 2003 by: J.A. Veil and M.B. Dusseault. http://www.ead.anl.gov/pub/dsp_detail.cfm?PubID=1584

Source: Shell Canada Ltd.

IN-GROUND SUMPS

SINGLE WELL SUMPS

Description

In-ground Sump: An impermeable pit, dug to contain drilling wastes. The pit is dug in low permeable material or permeable material made impermeable by some means.

In the Mackenzie Delta Region, the frozen ground provides the primary waste containment barrier.

Background

The petroleum industry uses sumps to dispose of drilling wastes.

When companies first started to use sumps for drilling wastes, the sumps were located near the drilling rigs. At that time, the permafrost conditions and the long-term management of the sump were not given much consideration.

Sumps adjacent to drilling rigs are still the preferred location of the Operators, however now; environmental conditions are taken into consideration, along with factors such as the sump design.

Before 1972, when the Territorial Land Use Regulations were enacted, there was little to no regulation of the drilling sumps. The sumps were often used to contain all sorts of waste material from the drilling operations.

Continued ...

Background Continued ...

After 1972, conditions were attached to the land use permits regulating waste that could be discharged to sumps. Even with these new conditions, some sumps (especially sumps used for summer drilling operations), still collapsed or failed, largely as a result of an inadequate design and poor management.

In 1987, the Department of Indian Affairs and Northern Development (DIAND) released a document entitled *"Environmental Operation Guidelines: Hydrocarbon Well sites in Northern Canada"* which provided some guidance in the planning, construction, operation and abandonment/restoration of sumps. At this same time, exploratory drilling in the Mackenzie Delta Region was declining so implementation of these recommendations is not evident today.

In 2002, S.V. Kokelj[1] determined that many abandoned sumps collapsed or failed because the permafrost, intended to contain the drilling waste thawed, allowing the release of the drilling wastes or the sumps held water and formed new "lakes" on the landscape. Kokejl stated that the waste must remain frozen and ice-bonded[2]:

> *"Sump reclamation involves capping the sump with backfilled material, aggradation of permafrost into the sumped materials and containment of the active layer within the sump cap so that the drilling fluids remain immobilized in the frozen ground."*

Also, Kokelj makes this recommendation:[3]

> *"The combination of warm permafrost temperatures and saline pore water can inhibit freeze-back and ice-bonding of sump fluids. In such cases the drilling wastes will remain mobile despite aggradation of permafrost."*

Continued ...

[1] S. V. Kokelj and GeoNorth Ltd. were hired to do research on drilling mud sumps in the Mackenzie Delta by the Department of Indian Affairs and Northern Development, Northwest Territories Region.

[2] Section 2.5 Abandonment Guidelines, page 7, of *"Drilling Mud Sumps in the Mackenzie Delta Region: Construction, Abandonment and Past Performance"* April 30th, 2002 by S.V. Kokelj and GeoNorth Ltd and submitted to the Department of Indian Affairs and Northern Development, Northwest Territories Region.

[3] Section 8: Recommendations: Number 5 page 44, of *"Drilling Mud Sumps in the Mackenzie Delta Region: Construction, Abandonment and Past Performance"* April 30th , 2002 by S.V. Kokelj and GeoNorth Ltd and submitted to the Department of Indian Affairs and Northern Development, Northwest Territories Region.

Background Continued ...

With the recent interest in natural gas development and the possibility of a Mackenzie Valley pipeline, a number of new wells are being drilled in the Mackenzie Delta Region so there is also a keen interest in the effectiveness of drilling sumps.

Are sumps failing? H. French states in a 1980 report on wells analyzed in the Mackenzie Delta, Arctic Islands and Yukon Territory[4]:

> *"A survey of over 60 abandoned well sites indicated that approximately 25% of the sites experienced terrain problems of varying magnitudes related either directly or indirectly to sumps and/or the containment of waste drilling fluids."*

Two main environmental concerns were identified and reported in 1988[5].

1. Physical disturbance of land may result from sump construction, sump failure, or reclamation procedures.
2. Chemical contamination of local surface and groundwater that could affect terrestrial and aquatic vegetation as well as, aquatic organisms.

In order to answer the question, "Are sumps failing?" we need to define sump failure. For example: If a sump traps snow that insulates the sump cap, water may pool during the summer resulting in the permafrost thawing and increasing the risk of a release of sump wastes. Is this a sump failure?

Kokejl[6] adds:

> *"An assessment of sump performance indicated that approximately 50% of sumps constructed in the Mackenzie Delta region during the 1970's have collapsed or are actively collapsing. Degradation of the sump cap indicated that drilling wastes were no longer immobilized in frozen ground."*

---

[4] H. French summarized results from analyzed well sites in the Mackenzie Delta, Arctic Islands and interior Yukon Territory appear in the report: *"Terrain, Land Use and Waste Drilling Fluid Disposal Problems, Arctic Canada"* 1980.

[5] ESRF funded research conducted by Hardy BBT Ltd. and Stanley Associates Engineering Ltd. See Report No. 93, February 1988 titled: *"Handling and Disposal of Waste Drilling Fluids from On-Land Sumps in the Northwest Territories and Yukon"*. Find the cited concerns on page 19, 4.1.2.

[6] Executive Summary page 1, of *"Drilling Mud Sumps in the Mackenzie Delta Region: Construction, Abandonment and Past Performance"* Prepared by S.V. Kokelj and GeoNorth Ltd and Prepared for the Department of Indian Affairs and Northern Development, Northwest Territories Region.

Background Continued ...

'Sump failure' is defined for the purposes of this guide: Conditions leading to the thawing of the permafrost which was intended for drilling waste containment and which could result in the release of sump wastes into the surrounding natural environment.

Conversely, a **sump collapse is defined** as: The natural settlement of a sump cap or pooling of water in the sump excavation zone without the release of sump wastes to the natural environment.

Note: Sump collapse is not necessarily a sump failure, however, these conditions may increase the risk of a sump failure.

Past Practices

In the past, for convenience, sumps were almost always located near to the drilling rigs. Factors, such as the examples below, were not taken into consideration:

- The distance to water bodies;
- Areas of massive ground ice;
- The depth of the active layer;
- Waste characteristics;
- Poor soil conditions;
- Ground thermal conditions; and,
- The terrain.

The drilling fluids used in the past tended to be environmentally unfriendly, containing heavy metals and other contaminants.

Sumps were often used as garbage dumps and as such, could contain scrap metal, cables, wood and waste oils.

Current Status

In-ground sumps are currently the option being used in the Mackenzie Delta Region for water based drilling mud systems.

Continued ...

Current Status Continued ...

The petroleum industry has recognized the past sump problems and have turned their attention to minimizing the environmental risks at each of the sumps' phases: the siting, design; construction; use, abandonment and monitoring. Sumps are no longer used as garbage dumps.

Drilling technology has changed considerably over the last three decades. Up to 75%[7] of drilling wastes from the 1970s have been eliminated with the improved methods of solids control and management, reusing and recycling. As a result, the drilling waste volume has decreased.

Today the drilling fluid components are evaluated with an environmental perspective.

Pros

The primary pros of using drilling sumps as the primary method of managing the drilling wastes are listed.

- **Operation Benefits** – In-ground sumps are preferred because of the:
  - **Low initial capital cost**; and,
  - **Overall operational convenience** – when the sump is adjacent to the drilling rig.
- **Legislation in-place** – Unlike other waste management options all the legislation is in place and no changes are required.
  - These sumps are regulated through the land use permits issued by DIAND or the Inuvialuit Lands Administration and Type 'B' water licenses issued by the Northwest Territories Water Board.
  - The conditions of the permits and licenses do not allow for the discharge of wastes from the sumps.

[7] In the 1970s and 1980s, drilling rigs generated approximately 1.0 to 1.3m^3 per meter drilled. The average waste generation today is 0.25 to 0.5 m^3 per meter drilled.

Cons

The cons of using drilling sumps a method of managing the drilling wastes are listed.

- **Controversy** – Recognition of the environmentally sensitive nature of the Mackenzie Delta Region along with past practices that resulted in sump failure or collapses has brought about disagreements on sump use .
- **Risk of sump failure** – There exists a risk of waste release into the environment, and possibly sump failure, if any or all the following are not done properly:
  - Siting;
  - Design;
  - Construction; and
  - Reclamation.
- **Salt-based muds** – Using salt-based drilling muds lowers the permanent freeze-back temperature and ice-bonding capability of the waste.
- **Surface Footprint** – The combined use of individual sumps leaves a greater impact on the landscape than a central or regional sump design..
  - The number of potentially contaminated sites in this sensitive environment has caused concerns to be expressed by different stakeholder groups.

Recommended Practices

See the 'Recommended Practices' within the following sections.

CENTRAL & REGIONAL SUMPS

Description

A Central Sump: A location where a single Operator constructs one or more sumps for use by multiple wells, and/or for multiple seasons.

A Regional Sump: Companies use a common site to construct their central sumps.

Current Status

Currently, smaller common remote sumps are being used.

Pros

The primary pros of using central and regional sumps managing drilling wastes are listed.

- **Site selection** – The best possible site for sump construction can be chosen before drilling begins.
- **Monitoring** – Using a single site makes monitoring and follow-up logistics (such as maintenance), easier.
- **Minimized impacts** – By reducing the number of sump sites a smaller footprint is left and broader impacts reduced.
    - Regional and central sump sites service larger geographical areas over multiple years.

Cons

The cons of using central and regional sumps managing drilling wastes are listed.

- **Waste transfer** – Getting the waste to a central site incurs added transportation, increases the risk of spills, and operational costs.
- **Seasonal Limitation** – Drilling waste generated in the summer may need to be stored and transported the following winter.

Continued ...

Cons Continued ...

- **Risk Potential** – The risk at one-site increases with the corresponding amount of drilling waste at that site.
- **Sump site management** – The use of one site by multiple companies would require additional management to ensure:
  - **No increased liability** for any one company due to others; and,
  - **No cross contamination** – With more than one sump at the site, companies must not deposit their drilling waste into the wrong sump and cause cross contamination.
- **Increased paperwork** – A separate land lease would be required (in addition to the drilling lease) which could cause a longer administration and review process, for each company's first well.
- **Practicality** – Individual Operator liability management issues could mean a common remote sump for more than one Operator may not be practical.

Recommended Practices

See the 'Recommended Practices' within the following sections.

SUMP SITING

If the petroleum industry is going to use in-ground sumps, there are a number of issues that need to be addressed. Perhaps of most importance is sump siting.

The major factors in sump siting are the local environmental conditions including:

- The local terrain;
- Location of water bodies;
- Soil conditions;
- On-site thermal regimes; and,
- Climate.

These factors must be taken into consideration in the design, construction, operation, abandonment and restoration of the sumps. Without careful consideration of these factors, there is potential for environmental impacts.

The Mackenzie Delta Region contains two different geographic areas controlled by the geology and the climate.

First is the Delta area itself, and the Tuktoyaktuk Coastal Lowlands, which are dominated by numerous small lakes and meandering river channels. In this area, river channels are prone to avulsions, usually caused by ice jam flooding.

To the east of the delta rise the Eastern Plains, with higher ground and fewer lakes. Ground ice features such as pingos and polygons are common throughout this area. Sump siting in either region will require different design criteria.

Recommended Practices

Minimize the possible impacts from in-ground sumps in the Mackenzie Delta Region, by practicing the following siting recommendations.

Conduct sump site selection surveys under non-winter conditions.

Continued ...

Recommended Practices Continued ...

Water Body Considerations

- Locate all sumps at least 100m away from any water body (including lakes, rivers, channels and seasonal runoff channels), as specified in land use permits issued by DIAND or the ILA.
- Conduct site surveys and review historical aerial photos to identify areas of active channel erosion and the potential areas of channel avulsions.
- Site sumps away from areas where channel erosion is occurring or could potentially occur, such as on the eroding side of a meandering stream.

Terrain Considerations

- Construct sumps on flat terrain, avoiding the toe or bottom of a slope to reduce the potential for runoff water to run into it and to avoid the pooling of water above the sump.
- Avoid areas that are prone to frequent flooding. Usually these are areas that are less than one meter in elevation, such as 'the Flats'.
- In areas that do not flood, establish the normal high water mark of the channel and site the sump away from this mark to prevent the sump from being flooded.
- Prevent snow accumulation around the sump edges by managing the surrounding vegetation and designing the sump cap to minimize snow traps.

Soil Considerations

- Construct the sump away from any gravel deposits since they can be very permeable.
- Avoid siting the sump in an area containing large ice lenses because if they melt they could cause a sump failure or collapse.
- Perform a proper soil characterization to determine soil suitability for an acceptable sump location..

Continued ...

Recommended Practices Continued ...

Thermal Regime

- Establish the local thermal regime in order to determine the range and extremes of the ground temperature and active layer where the drilling waste is to be buried.
    - Correlate the thermal regime to the expected freeze-point depression of the waste.
    - Ensure the maximum (warmest) ground temperatures and active layer depth that will be experienced in the sump, are adequate to maintain the long-term frozen state of the waste.

Fisheries, Wildlife & Habitat/Archaeological, Historical Significance & Areas of Traditional Harvesting

- Accommodate seasonal patterns of migratory birds and wildlife during summer drilling operations.
- Determine local conditions and conduct consultations during the planning phase of the operation, not during the application review.

Minimize Foot Print

- Use existing clearings, lines and roads, and river channels rather than developing new overland routes to access remote sumps.
- Consider the use of a central sump, when drilling multiple wells within the same season.

SUMP DESIGN

Past Practices & Impacts

Size

In exploration wells, the amount of drilling waste can change due to the well being deepened or unplanned events. Often, the past practices did not allow enough room for this increased drilling waste volume because of the following issues.

- The freeboard was normally 1.2 metres below surface, which allowed the possibility for the drilling wastes to encroach on the active layer.
- Inadequate allowances in volume were given for the summer drilling operations. (e.g. water seepage from active layer)
- In the summer season, the use of spoil piles, liners and insulation was not always successful.
- Limited solids control resulted in a larger footprint size.
- The surface runoff was not always considered.

Backfill Material

Sumps were blasted, which often resulted in large fill pieces and large voids in the material when the sump was backfilled. When this is not considered in the sump abandonment, there is increased potential for slumping and collapse.

Thermal

Sumps were assumed to remain frozen so there was little thought given to the conditions that could affect the permafrost such as the permafrost temperature versus the temperature at which the drilling fluids would start to thaw.

Soil Properties

Limited consideration was given to soil type or presence of ice lenses that could lead to the degradation of the active layer.

Current Status

The active layer in the Mackenzie Delta Region has a maximum thickness of about 1.5 metres, although this can vary throughout the region. The NWT Water Board has set the condition of 1 metre freeboard below the bottom of the active layer.

Sump design requires the accurate determination of the active layer of permafrost, at the location where the sump is to be constructed. This criterion allows for a safety zone between the expected minimum depth, or top of the buried waste, to the bottom of the active layer.

Recommended Practices – Winter

The following practices are recommended for designing in-ground sumps in the Mackenzie Delta Region in the winter, in order to minimize the possible impacts.

- Ensure a freeboard of 1 metre below the active layer is taken into account when determining sump size.
- Include adequate contingency in the sump dimensions to allow for increased volumes resulting from well deepening or unplanned events.
- Be prepared for the unexpected (e.g. massive ice or gravel) by having a plan for an alternate sump location.
- Design and construct the sump to minimize the footprint.
    - Construct a deep sump with vertical walls on three sides.
- Design the blasting for the sump to produce smaller particle sizes. This will:
    - Assist with reclaiming the sump; and,
    - Decrease the potential for sump collapse and drilling waste seeping out of the sump.

Recommended Practices – Summer

Summer sump design is different from the winter sump design. These recommended practices should be followed along with the winter recommendations when designing in-ground sumps for the Mackenzie Delta Region in the summer, in order to minimize the possible impacts.

- Design the sump walls to be stable during the summer while minimizing the footprint.
- Ensure the sump design:
  - Has a capacity that allows for rain; and,
  - Eliminates the inflow of water from the surface or the active layer.
- Ensure the thermal design will keep the drilling waste in the sump.
  - Ensure the sump walls and bottom, remain frozen.
- Consider ice lenses in the material.
- Protect the spoil pile and surrounding area from thaw back in order to maintain the thermal integrity.

SUMP CONSTRUCTION

Past Practices

Sumps were created by blasting and occasionally by ripping where soils conditions permitted. Bulldozers removed material from the sump, resulting in a large footprint and spoil pile.

Current Practices

In addition to blasting and bulldozers, often tracked hoes are used in the digging of the sump, which keeps the footprint smaller.

Recommended Practices

Minimize the possible impacts of the in-ground sumps in the Mackenzie Delta Region, by practicing the following sump construction recommendations.

- 'Ice' the work area, to minimize the surface disturbance from the heavy equipment and the resulting permafrost impacts.
- Save the surface organic layer and/or surface soil, when practical, before blasting, and store this material in a separate pile for placement on the surface during restoration.
- Once the sump is constructed, survey and verify the soil characteristics to ensure they correspond with the design and siting criteria.
    - Include this data in the sump report.

SUMP OPERATIONS

Past Practices

Prior to efficient solids control equipment, large volumes (4,000 to 9,000 m^3 per well) of drilling wastes were discharged directly into the sumps.

Sumps were used as "garbage dumps" and anything could end up in it including cables, wood and waste oils.

Drilling products were not environmentally friendly; they contained heavy metals and different types of oils.

Current Practices

In-ground sumps are currently the only option being used in the Mackenzie Delta Region for water based drilling mud systems.

The petroleum industry has recognized the past sump problems and have turned their attention to minimizing the environmental risks at each of the sumps' phases: siting; design; construction; use, abandonment and monitoring. Sumps are no longer used as garbage dumps.

Drilling technology has changed considerably over the last three decades. Up to 75%[8] of drilling wastes from the 1970s have been eliminated with the improved methods of solids control and management, reusing and recycling. As a result, the drilling waste volume has decreased.

Today the drilling fluid components are evaluated with an environmental perspective.

---

[8] In the 1970s and 1980s, drilling rigs generated approximately 1.0 to 1.3m^3 per meter drilled. The average waste generation today is 0.25 to 0.5 m^3 per meter drilled.

Recommended Practices

Minimize the possible impacts of operating in-ground sumps in the Mackenzie Delta Region, by practicing the following recommendations.

- Orient the rig workers about proper waste management practices, including the minimum freeboard.
- Utilize the solids control technology to recycle the drilling fluids then, only discharge the wastes into the sump.
- During the drilling phase, deposit the waste in the sump in shallow layers to allow for thorough freezing.
- Use the sump only for drilling wastes.
- Monitor the drilling waste for the freezing point depression and ensure the permafrost thermal regime around the sump is not exceeded. This is done to maintain the long-term frozen state of the waste.
- Isolate any contaminants (i.e. waste oils / hydrocarbons) that could go into the sump and ensure they do not go into the sump.
- Ensure remote sumps are marked visibly, to protect people and wildlife.

SUMP ABANDONMENT & RESTORATION

Past Practices - Winter

In the 1970's sumps were backfilled by placing the spoil material over the frozen waste.

In the 1980's and 90's, sumps were backfilled while maintaining a two-metre cap and a two-metre overlap. Sometimes fresh (non-saline) water was placed over the drill fluids.

Drilling wastes were not always totally frozen before backfilling. The sumps were "squeezed" by pushing backfill into the sump. This may have caused unfrozen drilling waste to squeeze up along the walls and in the middle of the sump resulting in some drilling waste in the active layer zone.

Current Practices

Current practices of the last few years have included most of the recommended practices below.

Recommend Practices

Minimize the possible impacts of abandonment and restoration in the Mackenzie Delta Region, by practicing the following recommendations.

- At completion of drilling the well, mix the fluids discharged with sump spoil material at a 3:1 ratio or allow the discharged fluids to freeze in naturally prior to backfilling.
- Before backfilling, if large amounts of snow have accumulated in the sump, remove the snow.
- Backfill and compact the spoil material in shallow lifts.
- Keep the drilling waste a minimum of 1 metre below the active layer.
- Contour the sump cap so snow will not be trapped and accumulate there.
- Design the sump cap to protect the thermal integrity of the sump.
- Take into account the settlement profile of the sump cap so that the potential for a pond to form is minimized.
- Restore the sump area to promote revegetation.
    - Replace salvaged organic layer on top of the sump cap.
- Re-contour the site, if subsidence is impacting the containment of the drilling waste.

SUMP MONITORING

Past Practices

Visual monitoring of the sump was conducted until the final inspections and closure of the land use permit and water licenses.

Recommend Practices

Minimize the possible impacts of the in-ground sumps in the Mackenzie Delta Region, by practicing the following monitoring recommendations.

- Conduct an EM Survey to determine if there is any lateral movement.
- Measure and monitor thermistor readings to determine the thermal response of the drilling waste and controls.
- Conduct a visual inspection of the site for such things as drainage, slumping, vegetation response, and cap stability.
- Adapt the monitoring program to the changing conditions.
- Submit all the monitoring program data to INAC Water Resources Division for storage in the central database.

Additional Recommended Practices

(For Regional, Central & Remote Sumps)

In addition to the other recommended practices are these additional recommended practices to minimize the possible impacts of using central, regional and/or remote sumps in the Mackenzie Delta Region.

- **Site location** – Pick the optimum site based on:
  - The **local environmental conditions**; and,
  - An **access route** that is open most years.
- **Allow for weather** – Plan for storms that prevent transportation, by having back up in place.
  - Include actions such as temporary waste storage at the rig.
- **Site Requirements** – Include lighting, traffic control and emergency response (e.g. emergency shelter or trailer) at the central and/or regional sump locations.
- **Future site requirements** – Ensure the central and/or regional sump sites have enough area for future expansion.
- **Site management** – Each Company must manage their site to ensure no other company dumps in their sumps.
- **Avoid spills** – Transport drilling waste to the central or regional sump location in a manner that no leaks or spills will occur and in accordance with all applicable regulatory requirements.
- **Spill response** – In the event of a spill; report, respond and clean up as per all applicable regulatory requirements.

References & / or Related Information

Drinnan, R.W., M. Yunker, A. Gillam, N. Charchuk, R. Alers, and S.R.H. Davies. 1987. *Environmental Studies Revolving Funds Report No. 063: Options for Treatment and Disposal of Oil-Based Mud Cuttings in the Canadian Arctic.* Ottawa. 81 pp and appendices.

D.W. Smith and T.D.W. James. 1979. *Sump Studies III: Biological Changes in Permafrost Terrain Adjacent to High Arctic Oil and Gas Wellsites.* Prepared for: Arctic Land Use Research Program, Environmental Studies Division, Northern Environmental Protection Branch, Department of Indian Affairs and Northern Development.

H. M. French. 1978. *Sump Studies I: Terrain Disturbances. Environmental Studies No. 6.* Prepared for: Arctic Land Use Research Program, Environmental Studies Division, Northern Environmental Protection Branch, Department of Indian Affairs and Northern Development.

H. M. French. 1981. *Sump Studies IV: Permafrost Terrain Disturbances Adjacent to Exploratory Wellsites, Northern Yukon Territory. Environmental Studies No.19.* Prepared for: Arctic Land Use Research Program, Northern Environmental Protection Branch, Department of Indian Affairs and Northern Development.

Hardy BBT Limited and Stanley Associates Engineering Ltd. 1988. *Handling and Disposal of Waste Drilling Fluids From On-Land Sumps in the Northwest Territories and Yukon.* Environmental Studies Research Funds Report No. 093. Ottawa. 58p.

Northwest Territories Waters Act:
http://laws.justice.gc.ca/en/N-27.3/86671.html

Northwest Territories Waters Regulations:
http://laws.justice.gc.ca/en/N-27.3/SOR-93-303/154784.html

Spencer Environmental Management Services Ltd. 1986. *Environmental Operating Guidelines: Hydrocarbon Well-sites in Northern Canada.* Prepared for: Land Resources, Northern Affairs Program, Indian and Northern Affairs Canada.

S.V. Kokelj and GeoNorth Ltd. 2002. *Drilling Mud Sumps in the Mackenzie Delta Region: Construction, Abandonment and Past Performance.* Prepared for: Water Resources Division, Indian and Northern Affairs Canada, Northwest Territories Region.

Territorial Lands Act: http://laws.justice.gc.ca/en/T-7/102457.html

Territorial Land Use Regulations:
http://laws.justice.gc.ca/en/T-7/C.R.C.-c.1524/181963.html

Notes:

Source: Pembina Area Landfill

REGIONAL TREATMENT & / OR DISPOSAL SITES (3RD PARTY OPERATOR)

Description

Regional Treatment & Disposal Sites (3rd Party Operator): A commercially operated venture by a third party which will accept drilling wastes from companies and, treat and dispose the waste in accordance with their water license and land lease conditions.

This could include numerous treatment and disposal options as discussed in this document.

Current Status

There are currently no regional treatment and / or disposal sites operated by a 3rd party, in the Mackenzie Delta Area.

Pros

The primary pros of a third party owning and operating a treatment and disposal site for the region are listed.

- **Reduced disposal costs** - The disposal costs for each company may be reduced.
- **Consistent disposal approaches** - One operator managing a regional drilling waste site, could result in consistent waste management approaches to the treatment and /or disposal of each type of drilling waste.
- **Inspection Ease** - Inspectors could more easily monitor the operation of one site versus many sites.

Continued ...

REGIONAL TREATMENT & DISPOSAL SITES (3RD PARTY OPERATOR) Continued ...

Pros Continued ...

- **Smaller footprint** - The landscape impacts of one regional drilling waste treatment and/or disposal centre would be smaller than the combined footprints of many sites throughout the Delta Area.
- **Environmental impacts minimized** - Depending on the type and volumes of drilling wastes, a 3rd party operator could utilize multiple treatment and disposal options to minimize the impacts on the environment.
- **Simplified approvals** - The water license and land use approvals would be simplified for each operating company.

Cons

The cons of a 3rd party owning and operating a treatment and / or disposal site for the region are listed.

- **Liability** - In the event that a 3rd party commercial operator could not handle the liability for the proper treatment and/or disposal of their drilling wastes, companies could end up sharing that liability.
- **Feasibility** - To be economically feasible, sufficient and long-term waste volumes are required.
- **Approval timeframes** - Approvals for a 3rd party commercial operator to get a water license and land lease, may take longer than the time required for individual companies to get the licenses and permits for other disposal options.
- **Seasonal access** - Well sites may need to store summer wastes and transport out to a regional facility during the winter.
- **NWT Water Act** - The regulations under the Northwest Territories Water Act would need to be amended to allow a 3rd Party Operator to dispose of drilling waste other than to a sump at a regional treatment and/or disposal site with a Type B water license.

REGIONAL TREATMENT & DISPOSAL SITES (3RD PARTY OPERATOR) Continued ...

Recommended Practices

Minimize the possible impacts of a regional treatment and/or disposal site by practicing the following recommendations.

- Companies must exercise the due diligence necessary to ensure the third party operator is managing the waste properly.
- Government and ILA inspectors must conduct regulatory inspections and audits.

References & / or Related Information

Drinnan, R.W., M. Yunker, A. Gillam, N. Charchuk, R. Alers, and S.R.H. Davies. 1987. Environmental Studies Revolving Funds Report No. 063: Options for Treatment and Disposal of Oil-Based Mud Cuttings in the Canadian Arctic. Ottawa. 81 pp and appendices.

North American Lake Management Society – Lake and Water Word Glossary: http://www.nalms.org/glossary/glossary.htm

Northwest Territories Waters Act:
http://laws.justice.gc.ca/en/N-27.3/86671.html

Northwest Territories Waters Regulations:
http://laws.justice.gc.ca/en/N-27.3/SOR-93-303/154784.html

Spencer Environmental Management Services Ltd. 1986. Environmental Operating Guidelines: Hydrocarbon Well-sites in Northern Canada. Prepared for: Land Resources, Northern Affairs Program, Indian and Northern Affairs Canada.

Alberta Special Waste Treatment Facility:
http://www.townofswanhills.com/aswt.html

Territorial Lands Act: http://laws.justice.gc.ca/en/T-7/102457.html

Territorial Land Use Regulations:
http://laws.justice.gc.ca/en/T-7/C.R.C.-c.1524/181963.html

Notes:

Thermal Desorption, Source: Nelson Environmental Remediation Ltd.

THERMAL DESORPTION / OXIDATION & INCINERATION

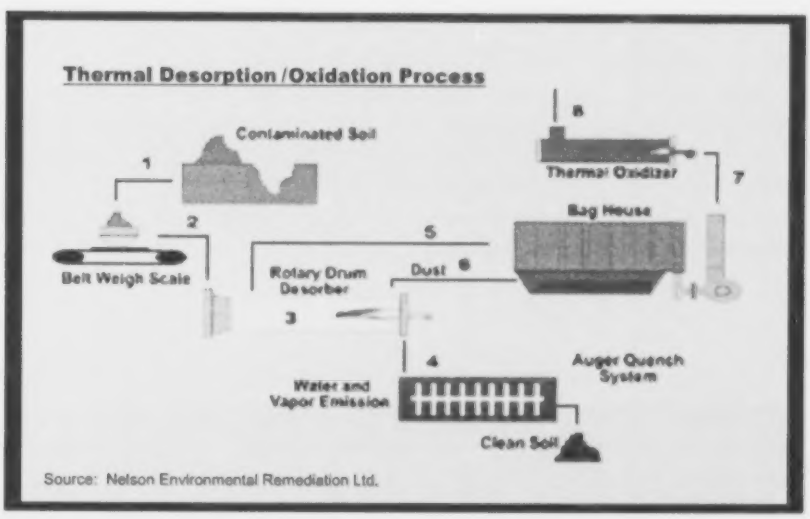
Description

Thermal Desorption / Oxidation: The contaminated waste is heated up to 650 C by a series of equipment to evaporate the water and hydrocarbons. The hydrocarbons are then thermally oxidized at temperatures over 850 C.

Incineration: The direct burning of waste at high temperatures. This option has been tested in cement kilns for use on drill cuttings.

Current Status

Neither thermal desorption / oxidation or incineration have been used in the Mackenzie Delta Region.



THERMAL DESORPTION / OXIDATION & INCINERATION Continued ...

Pros

The primary pros of dealing with drilling waste through thermal desorption / oxidation and/or incineration are listed below.

- **No hydrocarbons** - No hydrocarbons are left in the remaining waste.
- **Emission standards** - The regulatory emission standards can be met or exceeded.
- **Re-use** - The resulting end product can have other uses. (e.g. Bricks have been made from the inert rock particles.)

Cons

The cons of dealing with drilling waste through thermal desorption / oxidation and/or incineration are listed below.

- **End product is sterile** - Nothing will grow in the end product.
- **End product placement** - When the end product is dispersed, it must be placed below the organic layer where vegetation growth is desired.
- **Equipment limitations** - The hydrocarbons concentrations in oil drilling waste are too high for the current thermal desorption equipment.
    - The waste must be uniformly blended with clean material (e.g. clean end product), before undergoing the thermal desorption / oxidation process to lower the hydrocarbon concentration.
- **Fuel required** - The equipment involved to conduct this option requires fuel. (e.g. propane, natural gas, diesel)
- **Feasibility** - To be economically feasible large waste volumes with low hydrocarbon concentrations are required.

THERMAL DESORPTION / OXIDATION & INCINERATION Continued ...

Recommended Practices

The following practices are recommended to minimize the possible impacts.

- **Proper placement of end product** - When the end product is dispersed, it must be placed below the organic layer where vegetation growth is desired.
- **Demonstrate compliance** - Ensure the contractors involved have been certified and hold current regulatory approvals that demonstrate compliance.

References & / or Related Information

Northwest Territories Resources, Wildlife and Economic Development, *Environmental Protection; Acts, Regulations and Guidelines: Environmental Protection Act*. http://www.gov.nt.ca/RWED/eps/leg.htm

Northwest Territories Resources, Wildlife and Economic Development. *Environmental Protection; Programs and Publications: Air Quality Program*. http://www.gov.nt.ca/RWED/eps/environ.htm

Environmental Protections Services, Department of Resources; Northwest Territories Resources, Wildlife and Economic Development. Air Quality Code of Practice Upstream Oil & Gas Industry: Consultation Draft. September 2002. http://www.gov.nt.ca/RWED/eps/pdfs/airquality_codeofpractice.pdf

Notes:

TRUCKING OUT OF NWT

Source: Petro-Canada

Description

Trucking Out of NWT: Drilling wastes can be loaded onto trucks suitable for transporting such waste. Waste can then be trucked to a suitable disposal facility. Acceptable disposal sites are currently located within the Provincial borders of Alberta or British Columbia.

Current Status

Drilling waste is not currently being trucked out of the Mackenzie Delta Region.

Pro

When the drilling waste is trucked out, no drilling waste is left in the Mackenzie Delta Region.

Cons

The cons of trucking drilling waste out of the Mackenzie Delta Region are listed below.

- **Finding a receiving facility** - The provinces may not accept NWT waste for treatment and/or disposal.
- **Accident Risk** - There is always the risk of an accident and spill during transportation.

Continued ...

TRUCKING OUT OF NWT Continued ...

Cons Continued ...

- **TDG Regulations** - Depending on the waste, transporting waste may require adhering to applicable Transportation of Dangerous Goods Regulations. (e.g. labels, signage, certified drivers)
- **Cumulative effects** - Trucking the waste can result in a number of impacts. (e.g. ground disturbance, air quality issues attributable to emissions associated with significant increase in fuel consumption)
- **Winter problems** - In the winter the waste can freeze into the trucks.
- **Waste preparation** - Solids wastes with high fluid content require stabilization prior to trucking

Recommended Practices

The following practices are recommended to minimize the possible impacts.

- **Meet regulations** - Know and ensure all regulations for the various federal, provincial and territorial jurisdictions are met.
- **Waste Containers** - Use containers for waste storage that minimize the risk of site spillage and/or contamination.
- **Waste Storage Areas** - Adequately size the waste storage transfer area to make it easy to access and adhere to proper procedures.
- **Transportation** - Use truck boxes that are lined, tarped, and are equipped with sealed end gates or equivalent containment
    - Depending on drilling waste characteristics, containers may require to be approved for transport by TDGR, Transportation Canada and have UN numbers.
- **Spill Response** - Know and follow the applicable federal, provincial and territorial spill response and reporting procedures.
- **Track Waste** – Use the best industry practices to track the drilling waste.

APPENDICES

Glossary

References

Glossary

Active Channel Erosion	The continual erosion of the cut bank side of a channel due to the meandering movement of a water body (i.e. river).
Active Layer	The top layer of ground subject to annual thawing and freezing in areas underlain by permafrost.
Aggradation	The building up of land surfaces by sedimentation or deposition of mineral matter resulting in the growth of a permafrost area.
Avulsion	A forcible separation or detachment; a sudden cutting off of land by flood, currents, or change in course of a body of water.
Cumulative Effects	The sum of all effects, direct and indirect, caused by action(s). This term is typically used in environmental assessments to indicate the total impact in terms of air and water quality, land disturbance, and effects on flora and fauna, both short and long term.
DIAND	Department of Indian Affairs and Northern Development http://nwt-tno.inac-ainc.gc.ca/index_e.htm
Drilling Wastes	Drilling fluids and drill cuttings that are produced from drilling a well.
Environment	The air, land and water, layers of atmosphere, organic or inorganic matter and living organisms, or any combination or part thereof.
Environmental Risk Management	Managing the potential for harm anticipated from adverse environmental impacts generating from, or migrating onto, a site that is greater than what might ordinarily be encountered in daily life or during performance of routine work activities.
ESRF	Environmental Studies Research Funds
Footprint	The impact of a physical facility or operation upon the local environment.
Freeboard	Distance between two areas of concern. In the context of sumps, freeboard is the distance between either, the ground surface, or the bottom of the active layer, and the top of the drilling waste.

Glossary Continued ...

Ground Disturbance	Any impact caused to the vegetation or the soils.
Ice Wedge	A massive, generally wedge-shaped body of commonly white ice, with its apex pointing downward, composed of foliated or vertically banded. The surface expression of ice wedges is generally a network of polygons.
ILA	Inuvialuit Land Administration http://www.irc.inuvialuit.com/corporate.ila.description.asp
Impermeable	Not easily penetrated. The property of a material that does not allow, or allows only with great difficulty, the movement or passage of fluid.
Influx	Inflow of material.
Land Use Permit	A Land Use Permit issued for a land use operation in the Inuvialuit Settlement Region. On Crown Lands, these permits are issued by the Department of Indian Affairs and Northern Development. On Inuvialuit Private Lands, these permits are issued by the Inuvialuit Land Administration.
Meandering	The turn of a stream, either live or cut off. The winding of a stream channel in the shape of a series of loop-like bends.
Permeable	The movement or penetration of fluid through a material. **Low Permeability:** Very little fluid, travels through a material for a very small distance over a long period of time. (See Impermeable) **High Permeability**: A lot of fluid moves quickly through material for a long distance in a short period of time.
Pingo	A low hill or mound forced up by hydrostatic pressure in an area underlain by permafrost.
Permafrost	Ground (soil or rock) that remains at or below $0^{o}C$ for at least two years.
Polygon	A type of patterned ground consisting of a closed, roughly equi-dimensional figure bounded by more or less straight sides; some of the sides may be irregular.

Glossary Continued ...

Porosity	In rock or soil, it is the ratio (usually expressed as a percentage) of the volume of openings in the material to the bulk volume of the material.
Reclamation	To restore, as much as possible, the native soil profile and vegetation of a disturbed area.
Solids Control	The process of removing drill solids contained in the mud system. Examples of solids control equipment include; tanks, shakers, screens, centrifuges, desanders and desilters.
Water Board	The Northwest Territories Water Board, established under the *Northwest Territories Waters Act*, is responsible for the issuance of water licenses in the Inuvialuit Settlement Region.
Water Body	The water occupying or flowing in a particular bed (e.g. lake, pond, river).
Water Licenses	A Type A or a Type B water license allows the use of waters or the deposit of waste, or both. Type A: In the context of sumps, a Type A water license is issued for the disposal of drilling waste other than to a sump. Type B: In the context of sumps, a Type B water license is issued for disposal of drilling waste to a sump.
Wastewater	Water with waste materials or pollutants dissolved in it.

References

The references below include websites, publications and contacts for information related to Drilling Waste Management and the Mackenzie Delta Region.

Alberta Environment: http://www.gov.ab.ca/env

Alberta Environment Utilities Board: http://www.eub.gov.ab.ca

BC Ministry of Environment, Land and Parks : http://www.gov.bc.ca/elp

Canadian Association of Petroleum Producers (CAPP): http://www.capp.ca

Canadian Council of Ministers of the Environment (CCME): http://www.ccme.ca

Department of Indian Affairs and Northern Development NWT Water Resources Division: http://nwt-tno.inac-ainc.gc.ca/rr_e.htm The general email address for the Water Resources Division is NorthwestTerritoriesWaters@inac.gc.ca

DIAND (Department of Indian Affairs and Northern Development): http://nwt-tno.inac-ainc.gc.ca/index_e.htm

Drinnan, R.W., M. Yunker, A. Gillam, N. Charchuk, R. Alers, and S.R.H. Davies. 1987. **Environmental Studies Revolving Funds Report No. 063: Options for Treatment and Disposal of Oil-Based Mud Cuttings in the Canadian Arctic.** Ottawa. (81 pp and appendices)

Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories; Northwest Territories Water Board

Harris, S.A. et al. 1988. **Glossary of Permafrost and Related Ground-Ice Terms. Technical Memorandum No. 142.** Prepared for the National Research Council of Canada.

Inuvialuit Land Administration: http://www.irc.inuvialuit.com/corporate.ila.description.asp

Merriam-Webster Online: http://www.merriam-webster.com/

Microbial Diagnostics: Microbial Contamination and Indoor Air Quality – Glossary: http://www.geomology.com/glossary.htm

National Energy Board: http://www.neb-one.gc.ca

Northwest Territories Waters Act: http://laws.justice.gc.ca/en/N-27.3/86671.html

References Continued ...

Northwest Territories Water Board: http://infosource.gc.ca/Info_1/NTW-e.html

Northwest Territories Waters Regulations:
http://laws.justice.gc.ca/en/N-27.3/SOR-93-303/154784.html

Northwest Territories Resources, Wildlife and Economic Development:
http://www.gov.nt.ca/RWED

Offshore Oil & Gas Approvals in the Northwest Territories - Inuvialuit Settlement Region (Draft; April 2001). Available through the Canadian Association of Petroleum Producers (CAPP) or the Northern Oil & Gas Directorate in Ottawa.

Petroleum Communication Foundation: http://www.pcf.ab.ca

Saskatchewan Environment: http://www.se.gov.sk.ca/
Schlumberger Oilfield Glossary: http://www.glossary.oilfield.slb.com

Spencer Environmental Management Services Ltd. 1986. **Environmental Operating Guidelines: Hydrocarbon Well-sites in Northern Canada.** Prepared for: Land Resources, Northern Affairs Program, Indian and Northern Affairs Canada.

Summary of Guidelines for Canadian Drinking Water Quality:
http://www.hc-sc.gc.ca/ehp/ehd/catalogue/bch_pubs/summary.pdf

North American Lake Management Society – Lake and Water Word Glossary:
http://www.nalms.org/glossary/glossary.htm

Territorial Lands Act: http://laws.justice.gc.ca/en/T-7/102457.html

Territorial Land Use Regulations:
http://laws.justice.gc.ca/en/T-7/C.R.C.-c.1524/181963.html

The Mackenzie Delta Upstream Petroleum Industry's HSE Guide.
http://www.psc.ca or http://www.pits.ca

United States Environmental Protection Agency: http://www.epa.gov